WBA fact sheet

SMALL SCALE BIOMASS HEATING

SUMMARY

Worldwide more than 75% of all biomass is used for cooking and in small-scale heating devices (for space and water heating). This fact sheet has been produced to give an overview of various biomass heating systems below 100 kW, and their potential beneficial applications.

In many regions globally people are using old or outdated equipment with low energy conversion efficiency that can result in relatively high emissions. Yet, in the last decade, significant improvements in the technology of small-scale biomass combustion have been achieved. These improvements concern the preparation of the biomass fuel as well as the combustion technology, resulting in high efficiencies and a reduction of emissions by more than 90% as compared to the old equipment.

This fact sheet will provide information about the basics of biomass fuels, biomass combustion, new small scale biomass combustion technologies and the huge market for small scale biomass heat.

It is also intended to send a strong message to national governments globally to implement programs or incentives, to replace fossil fuels with biomass within the small scale heating market. Replacing fossil fuels has become specifically important for the future of global bioenergy policy, due to the fact that not only the heat market is the largest sector of final energy demand, but that biomass can offer a cost competitive solution.

INTRODUCTION

In the northern hemisphere about 50% of the final energy requirement is heat energy [1]. At present, district heating is uncommon globally, meaning that residential heating is mainly provided by burning fossil fuels in small-scale or by using electricity from the national grid.

Among the renewable sources of heat generation, biomass is the most significant source, responsible for over 90% of all renewable heat [2]. Wood is by far the most dominant fuel source for biomass heat generation.

An example of wood pellet stove with high efficiency, clean burning, and easy to use.
Photo: Duchessa idro, Narvells

TABLE 1:
CHEMICAL COMPOSITION OF WOOD

Elements	% share of dry matter
Carbon (C)	47 - 50
Hydrogen (H)	6.2
Oxygen (O)	43 - 45
Nitrogen (N)	< 0.1 - 0.4
Minerals	0.5 - 2

Source: [3]

THE HEATING VALUE OF BIOMASS

The energy content of biomass depends primarily on the moisture content of the biomass and the dry weight. The higher the moisture contents the lower the useful available heat. Part of the energy content of wet biomass is needed to evaporate the water present in the biomass. Also some water is formed during combustion by the combination of hydrogen and oxygen that are part of the dry matter of wood. The evaporation of 1 kg water requires 0.68 kWh (2.44 MJ).

TABLE 2:
NET CALORIFIC VALUE OF WOOD IN RELATION WITH THE MOISTURE CONTENT

Example	Moisture content (%)	Net* Calorific Value (kWh/kg)	Net* Calorific Value (MJ/kg)
Bone dry wood	0	5.1	18.5
Pellets	10%	4.7	16.9
Firewood, air dried several years	20%	4.0	14.4
Wood dried one year	30%	3.4	12.2
Saw mill residues	40%	2.8	10.0
Freshly harvested wood	55%	2.0	7.2

Source: [4]

*** Net Calorific Value (NCV)**
The quantity NCV known also as lower heating value (LHV) is determined by subtracting the heat of vaporization of the water vapor from the Gross Calorific Value (GCV). This treats any H_2O formed as a vapor. The energy required to vaporize the water is therefore not realized as heat.

Gross Calorific Value (GCV)
The quantity GCV known also as higher heating value (HHV) is determined by bringing all the products of combustion back to the original pre-combustion temperature, and in particular condensing any vapor produced.

WOOD FUELS FOR SMALL-SCALE HEATING

Firewood

Firewood is the dominant biomass fuel for traditional use but is also popular in modern small boilers. The moisture content of firewood determines how well it burns and how much heat is released per kilogram of wood. The drier the wood, the more useful heat energy will be released.

Wood chips

Wood chips are a typical biomass fuel for bigger installations of capacity above 100 kW. There are exceptions in use for small-scale heating on farms or forest estates. To equal the energy of 1.000 liters heating oil (1 m^3) a storage volume of 12 to 15 m^3 chips is needed. This high storage volume is considered the biggest problem considering the use of chips in small-scale heating.

Wood pellets

Wood pellets can be seen as a major heating fuel for the 21st century. Pellets are small, standardized, cylindrical and densified wood pieces with moisture content below 10%, that can be transported economically, burned completely and suit an automated feeding process. Due to pellets' high density, the storage volume is significantly reduced compared to firewood or wood chips. For example, to store the energy equivalent of 1 m^3 heating oil, only 3 m^3 (2 tons) of pellets are required. Pellets are increasingly available. Today, worldwide, there are more than 600 pellet plants in operation [5]. In 2010 the global wood pellet production reached 14.3 million tons.

THE IMPROVED COMBUSTION TECHNOLOGY OF WOOD FUELS

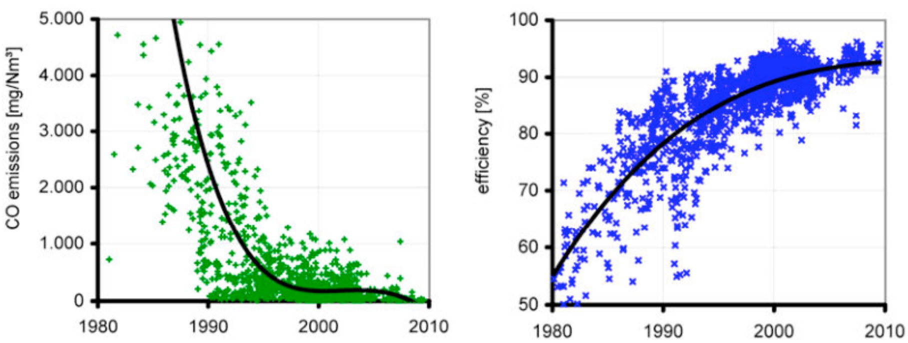
The perfect and complete combustion of wood should only produce CO_2, H_2O, some ash and, most importantly, heat energy. In the real situation the combustion of wood, especially in older stoves and boilers, is far from perfect since harmful particulates and gases are emitted due to incomplete combustion.

Combustion of a piece of solid biomass fuel proceeds in three stages. It starts with heating and drying, followed by the formation and combustion of volatile gases and finally the combustion of charcoal. [6]

The improved understanding of the wood combustion process has led to the construction of new types of wood boilers. These new boilers supply metered air to various combustion areas and employ sophisticated flue gas treatments.

Whereas traditional wood boilers may reach an efficiency of 30% to 40%, and produce a lot of smoke and other emissions, modern high-tech boilers reach efficiencies above 90% and result in a tremendous reduction of emissions as is shown in Table 3 and Figure 1.

Figure 1:
Efficiency and CO emissions of small-scale wood boilers



This figure shows how small scale wood boilers efficiency have been increased and CO emissions decreased the last 30 years of technological improvements.

Source: [13]

TABLE 3: THE IMPROVEMENT OF SMALL-SCALE WOOD COMBUSTION DUE TO TECHNOLOGICAL INNOVATIONS

	Unit	Firewood boilers 1980's	Firewood boilers 2010
Efficiency	%	30 - 40	above 90
CO	mg/MJ	10 000	30
Organic C	mg/MJ	300	1
Particles	mg/MJ	500	below 10

Source: [7]

AVAILABLE EQUIPMENT FOR SMALL SCALE HEATING WITH WOOD

Firewood stoves

These stoves can be used to heat single rooms or small houses and are available with outputs from 3.5 kW to 20 kW [8]. Stoves can be found in wide variations in design, such as doors with or without viewing glass or casings of tiles or soapstone. Thermal efficiency of modern fire wood stoves may be as high as 80%.

Firewood boilers

Firewood boilers are more suitable for houses and they are popular in rural areas. Firewood boilers are designed to burn larger pieces of wood than wood stoves. Wood is manually loaded into the appliance, and their capacity range is between 15 kW to 70 kW [8]. The technology has been improved dramatically; Two-stage combustion with automatic ignition, blower fan and reduced heat losses are examples of these improvements [9]. Modern firewood boilers achieve efficiencies of more than 90%.

Wood chip-fuelled boilers

Wood chip-fuelled boilers may be used to provide heat in larger houses, for farm buildings, or for industrial furnaces. Automatic operation and lower emissions because of continuous combustion are the advantages of wood chips heating systems compared with firewood boilers. Wood chip-fuelled boiler power capacity ranges from between 15 kW to 100 MW [10].

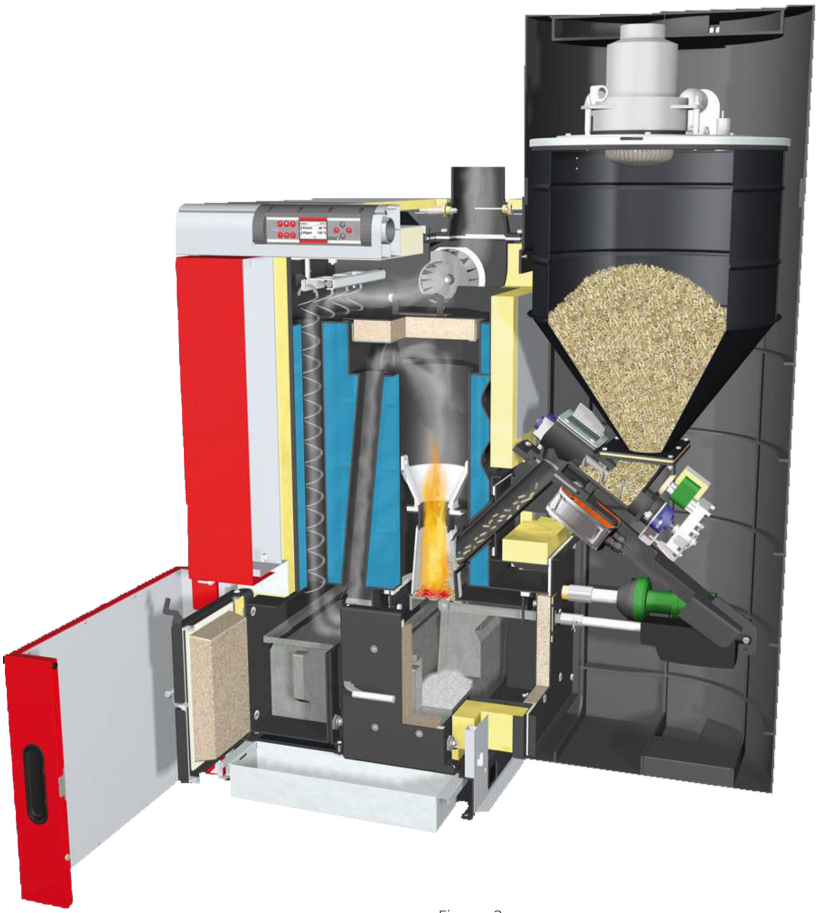


Figure 2.
A wood pellet boiler with store containers, automatic pellet feed and automatic ignition.
Illustration: Fröling, P4 pellet boiler

> "Modern high-tech wood boilers reach efficiencies above 90%."

Figure 3.
An example of a pellet boiler with a solar heating system. This system can easily provide space heating and hot water all year round.
Illustration: Baxi

Wood pellet stoves

Pellet stoves are more sophisticated than firewood stoves. Pellet stoves usually have a small fuel pellet storage, from which the pellets are conveyed by a small auger to shaft from where they fall into the combustion chamber [10]. A fan provides the air needed for combustion.

Advantages as compared to firewood stoves are: fully automatic operation, higher efficiency, cleaner burning, and easier to use [11]. Capacity range of domestic pellet stoves is between 1.5 kW to 12 kW.

Wood pellet boilers

Wood pellet boilers are used for capacities in the range 15 - 300 kW. These boilers are usually installed in a basement or in a separate container outside the house; fuel storage should be located close or next to the boiler room. Wood pellet boilers operate fully automatically, whether they are top feed, horizontal and underfeed burners. Ash removal is generally automated and the exterior ash box requires emptying once or twice a year.

Retrofit of oil boilers

External pellet burners can also be used to convert fossil-fuelled boiler facilities to using pellets. This way of retrofitting old systems can be a fast and cost-efficient way to convert to use pellets as a fuel.

Combination of wood and solar heating

The combinations of a pellet, chip or firewood fuelled boiler or stove with a solar heating system can easily provide space heating and hot water all year round. A 'buffered' heat storage system for solar and biomass heat means that the efficiency of this kind of combined system can be very high [12].

SMALL SCALE BIOMASS HEAT, MARKET PERSPECTIVES AND ECONOMIC ISSUES

The competitiveness of small-scale biomass heating differs from continent to continent. For example, in Japan with pellets prices of 400 €/t, small scale heating is not very competitive. This is also the case in parts of North America because of very low gas prices. By comparison, in Central Europe pellets prices for the final consumer are between 220 and 250 €/t, which means that fuel cost in the 2012 is about 50% lower than for fossil fuels.

A hindrance for the faster development of small-scale heating systems is the higher investment cost as compared to fossil-fuelled alternatives. In many countries this obstacle is overcome by a CO_2 taxation of fossil fuels to improve the competitiveness of biomass (e.g. Italy, Sweden) or by government grants to private households or support to companies manufacturing small-scale biomass heating systems (e.g. Austria and UK).

The justification for a pro-active government policy in favor of small-scale biomass heating installations is obvious, as the final energy output for a given quantity of wood is three times higher than using the same quantity of biomass for the production of electricity, unless the electricity is produced in combined heat and power plants (CHP). In addition, the promotion of small-scale renewable heat is one of the cheapest strategies to reduce CO_2 emissions.

At present in the northern hemisphere hundreds of millions of homes use fossil fuels or national grid electricity for low temperature heating. Small-scale biomass heating offers an important renewable alternative for them. ■

POSITION OF WBA

The public policy for the deployment of renewables very often overlooks the significance of the requirement for heat energy. The heat energy sector is often the most important part of overall primary energy and biomass offers solutions with high efficiency and economic advantages for the consumers.

In the last few years the industry, together with the scientific community, achieved impressive technological breakthroughs: Modern biomass equipment for small-scale heating now have up to 99% less emissions than old equipment and reach an efficiency of above 90%.

WBA urges public authorities to re-evaluate the importance of biomass for production of heat energy, especially for the small-scale heat market and set up promotion programs for this energy sector, including the supply side, the training of installers, financial support for the installation costs and the awareness building among the public about this cost-competitive, CO_2-neutral energy option.

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